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Revealing the socioeconomic impact of small disasters in Colombia using the DesInventar database

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Small disasters are usually the product of climate variability and climate change. Analysis of them illustrates that they increase difficulties for local development—frequently affecting the livelihoods of poor people and perpetuating their level of poverty and human insecurity—and entail challenges for a country's development. In contrast to extreme events, small disasters are often invisible at the national level and their effects are not considered as relevant from a macroeconomic standpoint. Nevertheless, their accumulated impact causes economic, environmental and social problems. This paper presents the results of an evaluation of the DesInventar database, developed in 1994 by the Network for Social Studies in Disaster Prevention in Latin America. In addition, it proposes a new version of the Local Disaster Index developed in 2005 within the framework of the Disaster Risk and Management Indicators Program for the Americas, with the support of the Inter-American Development Bank.

Keywords: climate variability and change, DesInventar database, local development, Local Disaster Index, small disasters, vulnerability

Introduction

A disaster implies loss, damage and consequential impacts that the affected community is unable to absorb or mitigate and recover from using its own resources and reserves. The concepts of vulnerability and resilience play an important role due to their significant relation with the possible occurrence of disasters. Hence, a disaster is a social context or process, triggered by a natural, technological or anthropogenic phenomenon, which in its interaction with a susceptible medium causes intense alterations to the normal functioning of a community. With regard to disasters, some processes require special attention, including population growth, rapid urban development, international financial pressures, degradation of the planet, global warming and environmental change, and war. Based on a limited number of examples, one can conclude that urbanisation processes have been an important factor in damage caused by earthquakes in urban areas while population growth helps to explain the rise in the number of persons affected by floods and prolonged drought and deforestation boosts the chances of flooding and landslides (Wisner et al., 1994; Birkmann, 2006). Adhering to the hypothesis that there is a correlation between a lack of development and vulnerability and considering that absence of capacity to cope, recover and adapt also contributes to vulnerability, particularly taking into account climate variability and change, Cardona (2008) suggests that vulnerability originates in physical

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fragility or exposure, in ecological, economic and social weakness, and in a lack of resilience or ability to cope and recover. Seen from this human or social perspective, any attempt to understand vulnerability also requires a careful examination of the variables or contexts that contribute to human and livelihood vulnerability, such as the security or insecurity of buildings, infrastructure and the environment, the nature of institutions and social organisations, and levels of income and welfare. These explicatory factors then become a fundamental part of the equation and of an understanding of human or social vulnerability (Cardona, 2004).

The effects of natural hazard events of small or moderate size are typically not considered as 'disasters', although they share the same origins as large and extensive events. However, they cannot be underestimated because, in general terms, they typify the disaster risk problem of a city, country or region. This paper does not debate risk vis-à-vis extreme events with a long return period (Cardona et al., 2008a), but rather concentrates on the insular, real and daily risk that many communities are exposed to in rural areas and small and large cities. Most of these disasters are the product of socio-ecological processes associated with environmental deterioration and are connected to repetitive small hazard events such as avalanches, flooding, landslides and storms, as well as to lower-scale earthquakes and volcanic eruptions.

At present, the consequences of climate change worry numerous scientists and some politicians, especially because of increases in the effects related to risk and human insecurity (UNFCCC, 2007; UNDP, 1994). Yet, risk is mounting not only in relation to hazards due to climate variability, which climate change exacerbates. Other risk factors, such as the 'vulnerability' conditions and the need for 'adaptive capacity' to respond to the action of natural hazard events, must be viewed with the same urgency (Cardona, 2001; IPCC, 2001; Mansilla, 2000; Gallopin, 2007). Awareness of these risk factors is lacking due to a dearth of systematised information. Consequently, this paper presents data that illustrate the increase in 'small disasters' or 'invisible disasters', resulting from climate variability and mounting vulnerability due to economic, environmental and social issues. Climate change, therefore, might pose a serious problem for disaster risk not only with regard to the potential for future extreme events but also in relation to small and frequent disasters that destroy the livelihoods of the poorest people and intensify their inability to adapt, perpetuating vulnerability and poverty.

Since the beginning of the 1990s, some researchers in Latin America have presented the hypothesis that the effects of small and moderate events, accumulated over time, could be equivalent to or larger than the impacts of major disasters. One can verify this hypothesis by an analysis of the losses and damage reported in the DesInventar database, developed in 1994 by the Network for Social Studies in Disaster Prevention in Latin America (LA RED). This database is useful for evaluating the number of events, their effects in terms of deaths, injuries and destruction of crops and housing, and their economic costs, allowing for comparison with extreme disasters. This paper presents the results of an evaluation of the proneness of Colombia to small and chronic disasters and the type of impact they have had on local development

and the country from an aggregated perspective. The study detected the extent of spatial variability and the dispersion of vulnerability and risk in the country due to events that are rarely entered into international or even national disaster databases, but which pose a mounting development problem for local areas and, given their likely overall consequences, for the country as a whole.

The empirical work on Colombia is presented in three sections. The first section describes the database of small disasters in order to identify the strengths and weaknesses of available data and to show how the information was prepared for this research. The second section introduces a conceptual framework on the impact of small disasters to characterise the risk associated with this type of event. This section also quantifies the effects of small disasters and details their economic costs to illustrate their relevance. The third section contains the conclusions of the study, concerning not only Colombia but also other developing countries. These conclusions have resulted in the issuing of new risk concepts (ISDR, 2009), such as 'intensive risk', concerning the concentrated risk manifesting infrequently in specific locations, and 'extensive risk', concerning the diffuse risk manifesting frequently over wide territories.

The DesInventar database includes an assessment and complementary works by LA RED–OSSO (Southwest Seismological Observatory). These proved useful not only for this study but also for ongoing research endeavours with the Inter-American Institute for Global Change Research (IAI) (Wilches-Chaux, 2007) and the Disaster Risk and Management Indicators Program for the Americas of the Institute of Environmental Studies (IDEA) (Cardona, 2005, 2006; IDEA, 2005).

The DesInventar disaster database

The DesInventar database contains a historical inventory of disasters and a methodology for analysis. It consists of a software application that allows for gathering, systematising, organising and consulting information recorded in the system both from a spatial and temporal point of view, as well as for the development of an information capturing and analysis methodology that emphasises in particular the aspects listed below.

- The DesInventar database analyses small disasters as a set of adverse impacts on goods, infrastructure, lives and social relations caused by the interaction of socio-environmental and anthropogenic phenomena in given vulnerability conditions. It includes disasters with few effects (such as the destruction of a house—affecting five people—or frost-induced crop loss) but also considers disasters with large effects (such as the Quindio earthquake in Colombia in 1999).
- Disasters materialise in communities and their environment. Observation of disasters affects one's vision and understanding of them; therefore, they should be associated with various spatial scales, both to perceive small and 'invisible' disasters as an expression of daily risk construction, and to split up those disasters that affect large areas in multiple and different ways but that are singular to each affected community.

- Information that records exposition, vulnerability and risk conditions at all scales must be prepared using variables and indicators that, as far as possible, should be homogeneous in terms of both the effects and the trigger. There should be a common language that aims to achieve compromise between rigorous definitions and comparability of data at a continental scale.
- The scale of resolution of the inventory should provide information for municipalities or other stakeholders at the sub-national level that is comparable with other countries. In addition, it is possible to obtain a local or regional inventory with more detailed resolution. This information is also gathered with a lower resolution (such as for a department or a country).

DesInventar Colombia has been maintained, refined and updated by OSSO as part of the Project DesInventar of LA RED since 1994. It records information from 1914–2002, and contains a total of 23,386 entries. The information used and analysed in this paper covers a 32-year period (1971–2002) and is based on 19,202 entries. In the DesInventar database, as in other disaster databases, the information compiled does not pretend to shape the universe of disasters that have happened. In the best case, it is a wide sample of disasters and is limited by the characteristics of the information and its sources. It is permanently subject to debugs and complements, and thus is not free of errors.

Regarding the sources, one can distinguish four significant aspects in the case of Colombia:

- Until 1995, the principal source for the database was newspaper archives, with an emphasis on national newspapers (*El Espectador*a and *El Tiempo*) and, in some cases, regional papers (*El Colombiano* of Medellín, *El País* of Cali and *La Patria* of Manizales). Irrespective of the quality of the information, there is a bias in information gathering that privileges Antioquia, the coffee-growing zone, the Valle del Cauca and Bogotá/Cundinamarca, compared with other regions of the country. For other regions, only cases reported in national newspapers are recorded—the regional press is ignored. This implies that the quality of the recorded information on the regions is unequal.
- Since 1995, the main source has been the Disaster Prevention and Attention Directorate (DPAD) of the Ministry of the Interior, complemented by information from the media. As DPAD does not register 'all events', only those that require national support, this information coverage is probably more significant for small and medium municipalities and those departments with few resources (Arauca, Casanare, Caquetá, Costa Atlántica, Meta and Santanderes) than for big cities and the rest of the country, although press information helps to reduce the slant.
- Information on some regions of Colombia, such as Amazonia and Orinoquía, which have few inhabitants and are very far from the national centre, is practically non-existent for this period.
- Due to the origin of data, information on regional capitals and intermediate cities (more than 100,000 inhabitants in the census of 1993) is more complete than for the remaining municipalities.

In sum, data weaknesses and problems have been recognised and to some extent corrected or compensated for, as discussed in the next section. However, one must consider different factors in order to carry out an appropriate analysis of the information:

a. It is important to have available strong or robust variables, such as the type of event that caused a disaster, the date of occurrence and the geographical location. Other less robust variables are also useful for analysis, including the number of dead people, the number of destroyed and affected houses, and the number of casualties and affected people. This data comes from a comparison with other databases, such as EMDAT[2] (The International Emergency Disasters Database)–DesInventar (LA RED-OSSO, 2003). One can also aggregate affected crop hectares.
b. In quantitative terms, these less robust variables may present different problems (additional or generic 'prejudgment' of newspaper information) that necessitate a continuous and thorough assessment of data:
   - data from journalists often do not come from proven sources, and frequently contrast with other official sources, such as fire brigades and the Red Cross;
   - official sources that 'inflate' data due to certain political interests (such as 'Plan Torniquete' of the government (1995–98) for post-flood reconstruction along the Atlantic Coast (DGPAD, 1999)) are difficult to correct but one can make comparisons with other non-official sources; and
   - errors in data compilation.
c. Not all entries contain the same information due to the type of damage (for instance, if there is no damage to houses but there is to bridges) or no quantification ('a lot of damaged houses'). Furthermore, the original information may include only certain variables (damaged houses must have a corresponding number of casualties or affected people, although nobody lives there).
d. The category of 'affected people' often includes a high number of individuals that in 99 per cent of cases were without basic services for one or two hours or one or two days (for example, two million people lacked electricity in Bogotá).
e. From a spatial perspective, as the information is organised by municipality, three problems may occur: 1) some records taken at the regional and municipality level are not defined; 2) some records are taken at a level lower than the municipal level (commune, lane); and 3) some municipal divisions have changed and it is impossible to know which records correspond to which municipality.

Correcting and validating the database

Information was compiled using 19,202 records for the period 1971–2002, reflecting the aforementioned limitations. After a validation of the data based on these criteria:

- data on the suspension of public services (for instance, 1.5 million affected people in Medellín due to a two-hour power blackout) were excluded;

Table 1 Small and medium disasters in Colombia, 1971–2002

Period	Number of events	Percentage of total
1971–80	5,226	27.2
1981–90	5,405	28.1
1991–2000	7,063	36.8
2001–02	1,508	7.9
1971–2002	19,202	100.0

Source: DesInventar database, http://www.desinventar.org.

- a value was given to entries on affected people based on entries on destroyed or affected houses—estimates were conservative, assuming that only one family lived in each destroyed or affected house;
- given the disparity in criteria for differentiating between casualties and affected people, it was assumed that both cases (except for those referred to above) were the direct effect of diverse scales or intensity and hence they were integrated into the same variable; and
- other detected problems concerning the location of an event and computation errors were corrected.

After updating and adjusting the database, the information was analysed to confirm the relevance of small and moderate disasters and to determine their accumulated impact compared with extreme events from 1971–2002 as well as to assess the consequences for all municipalities where the affects of local disasters have been recorded.

Throughout these 32 years, several local events that oscillated between small and moderate affected Colombia (see Table 1).[3]

Small and moderate disasters

Usually, the risk of small disasters is not considered as relevant; nevertheless, small disasters are a social and environmental problem with significant implications. As noted above, these events are primarily related to persistent hazards such as avalanches, droughts, floods, forest fires and landslides, resulting from socio-ecological processes associated with climate variability and environment deterioration that affect, in a chronic way, the most fragile socioeconomic populations in rural and urban areas. In general, small and frequent disasters prevent sustainability of local human development and reveal in which areas of urban centres vulnerability is mounting and where new hazards are emerging or existing hazards are worsening due to inadequate economic, environmental and social processes.

Taking into account the aforementioned aspects and the report of Marulanda and Cardona (2006), the concept of intensive risk refers to concentrated risk manifesting infrequently in specific locations while the concept of extensive risk refers

to diffuse risk manifesting frequently over wide territories (Maskrey, 2008). Global disaster databases and risk indexes reflect principally patterns of intensive risk, given that extensive risk is largely invisible at a global level of observation. Extensive risk patterns only become visible at a national level of observation and a higher resolution and thus have been consistently ignored. Because of this invisibility, extensive risk has not been a driver of disaster risk reduction, which has focused chiefly on saving lives and mitigation of major economic loss. A central hypothesis of the *Global Assessment Report on Disaster Risk Reduction* (ISDR, 2009) is that whereas mortality and economic loss risks tend to be intensive, asset risks in sectors such as agriculture and housing are more extensive in character and have pervasive, negative impacts on the livelihoods and lives of poor urban and rural populations. Through testing of this hypothesis, the ongoing *Global Assessment Report* (ISDR, 2009) will construct strategies to make extensive risk relevant to both disaster and poverty reduction as well as to climate change adaptation.

Small and moderate disaster analysis, and consequently the definition of large events, raise diverse methodological problems, especially:

1) the threshold at which a disaster is considered large; and
2) which effects should be included or excluded in an analysis of small and moderate disasters, given the singular impacts registered in each territorial unit.[4]

While not pretending to have answers to these two problems, the analysis should be oriented to exclude information on effects related to large disasters.

Given that extreme events can paint a different picture of effects in a country or at a sub-national level and that the purpose of the research is to evaluate the effects of small and moderate disasters, we applied an outlier (or an extreme value) identification process, defining arbitrary thresholds. Although direct selection of large disasters is an acceptable procedure, it is difficult to define a large disaster if one attempts a systematic approach. The process of identification of outliers[5] detected the extreme main effects of large hazard events. Criteria for extreme values were selected taking into account when the value could be considered as very large. This means that, typically, the effects in a municipality are considered extreme when they are visible or notable at the national level. Values considered as extreme are: dead people (more than 500); injured people (more than 1,500); affected houses (more than 4,500); destroyed houses (more than 2,500); and hectares of destroyed crops (more than 80,000). Most of the cases identified as outliers related to large disasters but some of the others were associated with figures that are not reliable—for example, the data registered were greater than the number of inhabitants in a municipality. Hence, the outlier process also detected typing errors that could not be uncovered when the database was reviewed and corrected.

The selection of the outliers was based on the size of the impacts of the events, that is, some 'recognised' hazard events, in some municipalities, generate small or moderate impacts (they are within the thresholds abovementioned) and were used for the analysis.

Effects of small and moderate disasters

EMDAT of the Centre for Research on the Epidemiology of Disasters, Catholic University of Louvain, lists 97 events that occurred in Colombia between 1971 and 2002 and that fulfil at least one of the following conditions:

- 10 or more dead people;
- at least 100 affected people;
- declaration of an emergency state; and
- international assistance required.

In summary, there are events that, in some way, have demanded the attention of the authorities or have led to the generation of new reports. In other words, this database deals with visible disasters. However, beyond these notable disasters, there are hundreds, even thousands, of events that happened in the same time frame, but which are not listed in these statistics of international organisations. According to the DesInventar database, more than 19,000 events occurred in Colombia during this time, contrasting markedly with the 97 listed in EMDAT (LA RED–OSSO, 2003). A gross assessment of the damage and losses caused by small and moderate events in Colombia from 1971–2002 revealed that 9,475 people lost their lives, 1,745,531

Table 2 Effects of small and moderate disasters

Period	Number of dead people	Number of affected people	Destroyed houses	Affected houses	Hectares of damaged crops
1971–80	2,964	204,393	18,588	16,604	327,497
1981–90	3,812	608,180	19,754	16,044	738,743
1991–2000	2,394	871,374	50,465	163,051	964,450
2001–02	305	61,584	4,353	21,376	144,023
1971–2002	9,475	1,745,531	93,160	217,075	2,174,713

Source: DesInventar database, http://www.desinventar.org.

Table 3 Effects per local event on average

Period	Number of dead people	Number of affected people	Destroyed houses	Affected houses	Hectares of damaged crops
1971–80	0.57	39.11	3.56	3.18	62.67
1981–90	0.71	112.52	3.65	2.97	136.68
1991–2000	0.34	123.37	7.14	23.09	136.55
2001–02	0.20	40.84	2.89	14.18	95.51
1971–2002	0.49	90.90	4.85	11.30	113.25

Source: DesInventar database, http://www.desinventar.org.

people were affected, 93,160 houses were destroyed houses, 217,075 houses were affected, and 2,174,713 hectares of crops were destroyed.

During the 1990s, there were more effects and more records of small disasters. This period saw the greatest damage and losses, with the exception of the number of dead people. The figures are much higher than the average registered by local events over the 32 years studied, as illustrated in Table 3.

The last line of Table 3 shows the overall average values for the entire period studied. Damage and losses related to dead people, affected people, and hectares of destroyed crops for the decade 1981–90 were above average for the 32-year period, while only the number of dead people between 1971 and 1980 was above the average by event for the whole period. A comparison of the averages corresponding to the three decades 1971–2000 and the period 2001–02 reveals very high values associated with the latter.

Given that the quality of data since the 1970s is similar, two factors explain the rising trend in damage and losses caused by small disasters throughout these years:

- the increased intensity and the recurrence of hazard events; and
- the increased vulnerability and the quantity of exposed elements.

The escalation in hazard events is evident particularly in some hydrographical basins due to environmental degradation and perhaps to the gradients of climate variability (that is, climate change). Increased population growth and urbanisation over the past 40 years has resulted in a rise in the quantity of exposed elements and in their level of vulnerability. In any case, one can argue that accumulating risks in Colombia are the consequence of the rising number of natural and socio-natural hazard events connected to the development model that the country has implemented and perhaps to climate change.

In comparative terms, the damage and losses induced by small disasters during the period are notable. Table 4 provides a comparison with the biggest disasters suffered by Colombia in the 32-year study period: the Nevado del Ruiz volcanic eruption of 1985 and the Quindío earthquake of 1999.

Although the number of deaths in the volcanic disaster of 1985 represents an extraordinary event that exceeded the predictions of any specialist at the time, the

Table 4 Comparison of the effects of small and extreme disasters

Type of damage and losses	Nevado del Ruiz eruption (1985)	Quindio earthquake (1999)	Small disasters (1971–2002)
Number of dead people	24,442	1,862	9,475
Number of affected people	232,546	160,336	1,745,531
Destroyed houses	5,402	35,949	93,160
Affected houses	N/A	43,422	217,075
Hectares of damaged crops	11,000	N/A	2,174,713

Sources: DesInventar database, http://www.desinventar.org, and ERN-Colombia (2005).

sum of deaths caused by small disasters over time also is high, amounting to 38.8 per cent of the deaths that occurred in Armero and Chinchina—the cities most affected by the volcanic eruption. The number of people affected by small disasters is 7.5 times greater than the figure for large disasters and almost 11 times greater than the figure for the Quindio earthquake of 1999, which severely affected the entire coffee-growing region. Taking into account the total number of destroyed houses, the figure for small disasters is more than 2.5 times greater than the total for the Quindio earthquake and more than 17 times greater than the total for Armero and Chinchina in the Nevado del Ruiz volcanic eruption. The number of houses affected by small disasters is five times greater than that for the Quindio earthquake.

Economic cost of small and moderate disasters

Recorded losses due to small and moderate local events are very significant. For two categories of economic loss (damaged houses and hectares of damaged crops), the total amount over 32 years of study exceeds USD 1,650 million (see Table 5). Of this, 35.1 per cent corresponds to destroyed and affected houses while 64.9 per cent corresponds to hectares of damaged crops.

This approximation is useful for estimating the magnitude of losses and for making general comparisons.[6] Although in the case of crop losses overestimates are possible due to the valuation of errors or to difficulty in estimating the real surface area affected, one can easily observe that losses in the agricultural sector are very important although they are not so visible.

These are assumed values and they correspond neither to real reposition expenditures nor to any help provided by the government. The value of destroyed houses is assumed to be the average cost of a social housing unit according to existing standards in each country (number of square metres) during the period of analysis. In addition, the value per square metre of social housing is equivalent to one legally established minimum salary during the same time frame. However, it is proposed that the value of one hectare of crops be calculated on the basis of the weighted average price of crop areas usually affected, taking into account expert opinion in the country at the time of the analysis.

Table 5 Estimated losses and damage caused by small disasters (in thousands of USD)

Period	Losses: houses	Losses: crops	Total
1971–80	68,217.00	98,249.10	166,466.10
1981–90	78,424.50	295,497.20	373,921.70
1991–2000	385,892.33	578,669.70	964,562.03
2001–02	47,127.42	100,816.45	147,943.87
1971–2002	579,661.25	1,073,232.45	1,652,893.70

Source: based on the methodology of the Disaster Risk and Management Indicators Program for the Americas (IDEA, 2005).

In most cases, no formal reconstruction programme was introduced and no government loans or subsides were granted to affected people for reconstruction or recovery. Although these are only estimates, the figures illustrate the magnitude of the problem, which is worrying and often overlooked**.** Most affected people belong to low-income communities that have scarce resources and do not receive any recovery aid from the government when such events occur. Furthermore, they are affected repeatedly by such small disasters at the local level, losing their livelihoods. While this chronic situation may not be relevant from a macroeconomic standpoint, it perpetuates poverty and underdevelopment in the country. What is also troubling is that the adaptive strategies of low-income communities are unsuccessful at present and disaster resilience is diminished to cope with the effects of climate variability and climate change.

One can clearly observe in Tables 2 and 5 that losses have grown over time in a different way when compared with the respective number of events. Thus, between the 1970s and the 1980s, the number of events increased by only 3.42 per cent while losses saw an unexpected rise of 224.6 per cent. Whereas the increase in events from the 1980s to the 1990s was 130.68 per cent, losses witnessed extraordinary growth of 257.96 per cent. The average cost for each event from 1971–80, 1981–90 and 1991–2000 was 31,853 USD, 69,181 USD and 136,566 USD, respectively.

A comparative analysis of losses caused by small events and some of the recognised extreme disasters that resulted in massive destruction in Colombia is useful to determine the impact that small and moderate events have had over time. According to Table 6, material losses, in millions of current US dollars, due to small disasters over the 32-year period are 6.7 times greater than the losses caused by the Nevado del Ruiz volcanic disaster of 1985. Even aggregated losses due to small disasters between 1981 and 1990 are 1.5 times more than the losses caused by the same disaster in Armero and Chinchina.

When one considers the figures associated with destroyed houses and hectares of damaged crops it is clear that total losses due to small local events surpassed the material losses caused by the Quindio earthquake of 1999. This means that approximately every 30 years, losses to agriculture and housing due to small disasters are similar to those produced by a large event such as the Quindio earthquake. The major difference between the extreme and small disasters mentioned above is that for the

Table 6 Losses due to extreme hazard events, in millions of current USD and as a percentage of gross domestic product

Events	Estimated losses	Reconstruction costs
Eruption of Ruiz volcano (1985), Armero	246.05 (0.70)	359.95 (1.02)
Coffee region earthquake (1999), Quindio	1,590.81 (1.88)	856.72 (1.01)
Small and moderate events (1971–2002)	1,652.89	N/A*

* N/A means data not available. In most cases, though, the state has not made any direct investments.

Source: ERN-Colombia, 2005.

Table 7 Accumulated losses due to small disasters in millions of USD and as a percentage of agriculture GDP

Period	Crop losses in current (constant) USD	Agricultural sector GDP in current (constant) USD	Losses as a percentage of sectoral GDP
1971–80	98,25 (172.64)	6,466 (11,352)	1,52
1981–90	295,50 (689.50)	6,539 (15,257)	4,52
1991–2000	578,67 (758.38)	10,330 (13,358)	5.60
2001–02	100,82 (138.80)	10,103 (13,909)	1.00
1971–2002	1,073.24 (1,759.32)	(13.909)	(12.65)

* GDP data for the last year of each period were used for the estimate.

Source: World Bank (2003).

former, a programme of reconstruction was implemented and significant investments were made to aid affected people—in the case of the latter, no formal rehabilitation or reconstruction activities were initiated. Some people affected by small disasters received humanitarian aid, but most people did not get any substantial post-disaster aid for recovery and development.

Today, estimates of the economic impact of disasters are common, taking into account aggregated macroeconomic variables, such as gross domestic product (GDP). This has been the approach of the international financial institutions as well as of banks and agencies such as the Economic Commission for Latin America and the Caribbean (ECLAC). Although it is recognised that the economic losses do not correspond to the real impact of disasters, economic losses expressed as a percentage of national and sectoral GDP are certainly useful for illustrating the relevance of small disasters and their consequences for the national economy. In the agriculture sector, for example, small disasters have produced elevated levels of losses. Table 7 shows the accumulated losses for the period 1971–80, equivalent to 1.52 per cent of agricultural GDP in 1980. Small disasters had a more significant impact in the 1980s, with total losses in the agricultural sector representing 4.52 per cent of agricultural GDP in 1990. The figure rose again in the 1990s to 5.6 per cent of agricultural GDP in 2000. Losses in the sector are equivalent to 12.65 per cent of sectoral GDP, in constant prices, over the 32-year period. It is important to underline here that agriculture is one of the most important sectors of the country's economy.

Table 8 shows housing losses due to small disasters in terms of GDP of the construction sector. The losses are considerably smaller than those recorded in the agricultural sector, but the impact on sectoral GDP is larger. During the 1970s, the losses were equivalent to 4.25 per cent of construction sector GDP. In the 1980s and the 1990s, the proportions were 3.95 per cent and 12.62 per cent, respectively. In accumulative terms, damage to housing during the 32-year period represents 19.92 per cent of GDP in the construction sector, in constant prices. This is another important sector of the economy and vital source of employment in Colombia.

Table 8 Accumulated losses due to small disasters in millions of USD and as a percentage of construction GDP

Period	Housing losses in current (constant) USD	Construction sector GDP in current (constant) USD	Losses as a percentage of sectoral GDP
1971–80	68.22 (119.87)	1,607.20 (2,824.11)	4.25
1981–90	78,42 (182.98)	1,993.10 (4,650.58)	3.95
1991–2000	385.89 (505.73)	3,058.10 (4,007.80)	12.62
2001–02	47.13 (64.88)	3,184.95 (4,354.89)	1.48
1971–2002	579.66 (873.47)	(4.354.89)	(19.92)

* GDP data for the last year of each period were used for the estimate.

Source: World Bank (2003).

Table 9 Accumulated losses due to small disasters in millions of USD and as a percentage of the GDP of Colombia

Period	Losses (crops and houses) in current (constant) USD	National GDP in current (constant) USD	Losses as a percentage of national GDP
1971–80	166.47 (264.81)	33,400 (53,180)	0.50
1981–90	373.92 (688.05)	40,274 (74,108)	0.93
1991–2000	964.56 (1,129.24)	83,220 (96,652)	1.16
2001–02	147.95 (175.94)	84,002 (99,893)	0.18
1971–2002	1,652.89 (2,249.03)	(99,893)	(2.25)

* GDP data for the last year of each period were used for the estimate.

Source: World Bank (2003).

Finally, at an aggregated level, the impact of small disasters has been considerable. According to Table 9, total losses to the construction and agriculture sectors due to small disasters over the 32-year period represent 2.25 per cent of national GDP in 2002, in constant prices. This is significant given that the losses caused by the Quindio earthquake represented 1.88 per cent of national GDP in 1999.

Given the figures cited above for small disasters, it is difficult to refer to disasters without any impacts. Furthermore, one should note that the estimated losses do not include the cost of damage to infrastructure (such as bridges and roads) and to the productive sectors (such as commerce and electricity).

These figures are not only significant in quantitative terms but also one can consider them as evidence confirming the hypothesis that the effects of small disasters are equivalent and, in many cases, greater than those of extreme disasters, the impacts of which are highly visible. Nonetheless, small disasters remain 'invisible' and are not seen as matters of concern. The data above, however, illustrate their relevance, and underscore that they represent a worrying risk for all Latin American countries.

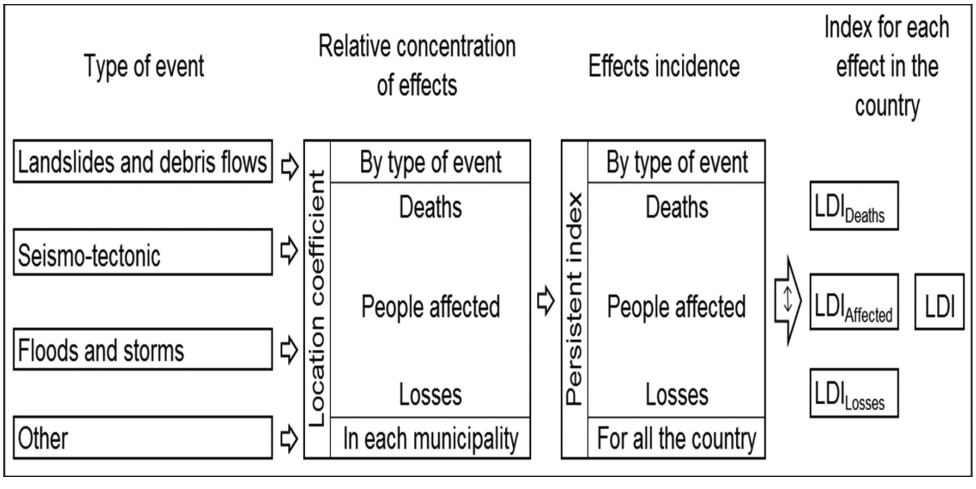
The next section presents a new version of the Local Disaster Index (LDI). The index was proposed and developed by the Institute of Environmental Studies (Instituto de Estudios Ambientales, IDEA) of the National University of Colombia in Manizales in 2005 within the framework of the Disaster Risk and Management Indicators Program for the Americas—with the support of the Inter-American Development Bank (IDB) (IDEA, 2005).[7]

New formulation of the Local Disaster Index

The LDI demonstrates the propensity of a country to experience small disasters and their cumulative impact on local development. It attempts to represent the spatial variability and dispersion of risk in a country resulting from small and recurrent events. The index captures simultaneously the incidence and uniformity of the distribution of local effects. That is, it accounts for the relative weight and persistence of the effects attributable to phenomena that give rise to municipal-scale disasters. If the relative value of the index is high, the uniformity of the magnitude and distribution of the effects of various hazards among municipalities is greater. A low LDI value means low spatial distribution of the effects among the municipalities where events have occurred—in other words, high concentration in some municipalities. Figure 1 illustrates schematically how the LDI is determined for a country based on information on events in each municipality.

The Disaster Risk and Management Indicators Program for the Americas evaluated the LDI (Cardona, 2005, 2006; IDEA, 2005) in 2005 taking into account the effects of extreme hazard events (Cardona et al., 2008b). That is, the assessment included the effects of all disasters: small and frequent as well as extreme and sporadic. For this reason, the original LDI would be better denominated as a Local Effects

Figure 1 LDI estimation



Source: Disaster Risk and Management Indicators Program for the Americas (IDEA, 2005).

Table 10 New LDI for dead people (K), affected people (A) and losses (L) without outliers

	1981–85	1986–90	1991–95	1996–2000	2001–02
LDI_K	70.63	83.21	75.22	76.20	82.15
LDI_A	67.69	8.62	62.12	78.00	62.15
LDI_L	5.44	28.54	11.26	14.81	1.07
LDI	143.75	120.38	148.61	169.01	145.37

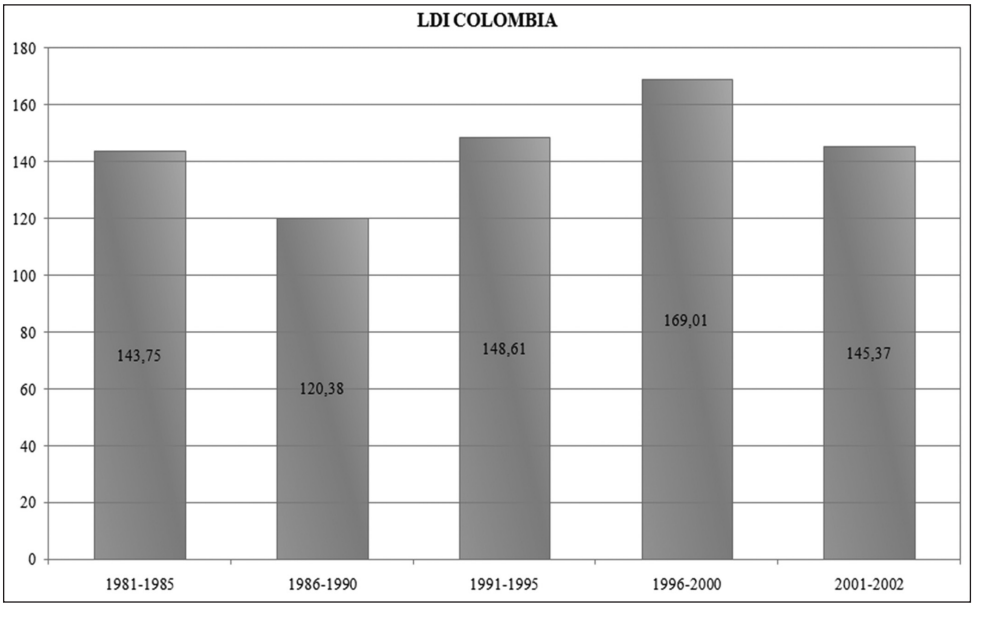
Source: based on the DesInventar database without outliers (Marulanda and Cardona, 2006).

Index (LEI). To create a real LDI the values should be based only on the effects of small disasters, mostly considered as local. Therefore, once the outliers have been obtained and excluded from the database, the results of the computed index would be seen as a real LDI. These results are very different indeed. This new version of the LDI illustrates that the accumulative impact may be highly significant at the local level and, consequently, highly significant at the national level from a social perspective. It attempts to represent spatial variability and dispersion of risk within a country, expressed in terms of the occurrence of smaller and more recurrent events.

Table 10 presents the new version of the LDI calculated without outliers. Overall, there is a rising trend in Colombia with regard to the effects of small disasters. Figure 2 plots LDI values in different periods.

In general, as the new LDI shows, small disasters have caused a rise in the incidence and uniformity of effects among all municipalities of the country in the period

Figure 2 Local Disaster Index Colombia, 1980–2002



Source: based on DesInventar database without outliers (Marulanda and Cardona, 2006).

evaluated. In relation to vulnerability assessment and policy implications, the increasing LDI reflects mounting vulnerability, environmental deterioration and hazard-event recurrence as a result of climate variability and probably climate change. LDI figures at the sub-national level allow one to identify vulnerability hotspots in the country or in urban areas of mega-cities. In addition, the LDI targets vulnerable populations that differ from those in large-scale disaster targeting due to frequent destruction of livelihoods in 'invisible' disasters. After familiarising themselves with the LDI, territorial planners, from the national and sub-national level, should use the gross data on municipalities to present possible corrective and prospective disaster risk reduction measures within the framework of development.

Conclusion

Application of the DesInventar database by other Latin American and Caribbean states has produced extremely positive results, particularly when a wide view is taken of the type of events that most frequently manifest in these countries. To date, the Colombian case study represents the most complete effort to apply this tool and the deepest analysis. It has not only allowed for a description of the frequent kinds of disasters that affect the country, but also it has permitted in some cases identification of their causes and effects, high priority zones and the impacts of small disasters on specific sectors and the national economy. Small disasters typically are not seen as very relevant from a macroeconomic perspective because they are usually not important for contingency liabilities and for the fiscal sustainability of a country—hence, they are often ignored. However, small disasters are certainly relevant from a social and microeconomic standpoint and, therefore, policymakers and planners should not ignore them.

The main objective of this paper has been to analyse the results of an evaluation of the proneness of Colombia to small and chronic disasters and the impact they have on local development and on the country from an aggregated stance. The analysis detected the spatial variability and dispersion of risk due to events that are rarely recorded in international or national disaster databases but which pose a serious and accumulative development problem for local areas and, given their probable overall consequences, for the entire country. In addition, the growing number of small disasters and their increasing consequences illustrate that the adaptive strategies of poor communities are less effective now because of recurrent destruction of their livelihoods and the reduction of disaster resilience among human settlements. Most of these disasters are the result of socio-ecological processes associated with environmental deterioration and with persistent small events such as avalanches, flooding, landslides and storms as well as lower-scale earthquakes and volcanic eruptions.

The analysis, considering the dispersion and persistence of effects at the local level, produced some interesting results and noted some significant implications for development. The old LDI of IDEA (the LEI) or the new LDI proposed herein as an alternative with a subtle variation reveal and measure Colombia's susceptibility to

small and recurrent disasters. They illustrate that the accumulative impact may be highly significant at the local level and hence, at the national level from a social viewpoint—small and frequent disasters prevent the sustainability of local human development.

These results allow one to stress that extreme disasters do not necessarily determine the history of disasters. Colombia's recent history has been dominated until now by major disasters, such as the Popayan earthquake (1983), the Nevado del Ruiz volcanic eruption (1985), the Tierradentro (Paez) earthquake (1994) and the Quindio earthquake (1999). By accepting the relevance of their effects on the population and the economy as a whole, one must recognise also that each year, many small and moderate disasters, which individually do not cause a high level of damage and loss, affect the population and diverse economic sectors due to their frequency and their accumulated impact over time.

The outcomes of this study will be of use to economic analysts and sectoral decision-makers responsible for urban policy development, because they can detect not only the potential effects of extreme events but also the persistence and accumulation of effects of small and local disasters. This will boost consideration of risk problems in territorial planning at the local level, protection of hydrographical basins and ecosystems, and implementation of resource transfer and collective insurance programmes to cover the losses of poor communities. This research reveals that the aggregated impact of small disasters and the effects of extreme events also lead to fiscal exposure and contingent liability on the part of the government to provide compensation for housing and to recover the livelihoods of the poorest people.

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[2] See http://www.emdat.be/.

[3] For a breakdown of the figures in Table 1 according to type of event, see Marulanda and Cardona, 2006.

[4] The DesInventar database contains information on effects according to municipality, not event.

[5] Outliers are obtained using statistical and data-mining techniques.

[6] The methodology proposed by the Programme of Disaster Risk Management Indicators, IDB–IDEA (IDEA, 2005; Cardona, 2005) was applied to calculate losses caused by small disasters. In the case of houses, we considered the total number of destroyed houses plus affected houses, with four affected houses corresponding to one destroyed house. The estimation of loss was made by assuming the reposition of a social interest house (average value of built square metres in each period) and without considering the cost of land. The estimation of crop losses was based on the average cost of typical hectares of crops in flooded zones.

[7] Fundamental technical details on the LDI can be found in the *Main Technical Report* of the Disaster Risk and Management Indicators Program for the Americas, http://idea.unalmzl.edu.co (Cardona, 2005; Cardona, 2006; Marulanda and Cardona, 2006). The mathematical details of the LDI are beyond the scope of this paper. Interested readers should see the aforementioned references.

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